KEYNOTE ADDRESS

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WOOD PRESERVATION RESEARCH FOR THE FUTURE

Summary:

The wood preservation field has an important role to play in promoting the use of wood products and constructions in the future. The preservation field will have to rely mainly upon the established preservatives and treatment methods for some time yet. However, the environmental safety has been and can still be improved by improved products, processes and treatment practices. The industry must be prepared to invest more resources to the R & D work towards this goal. In order to open new ways of wood protection more basic research, preferably in international co-operation, is needed.

1. Introduction

Recent progress and further challenges in the field of wood preservation research are discussed in this paper. The presentation is not by far meant to be a comprehensive overview of wood preservation research. The point of view is mainly Nordic and European, but I hope it can offer an interesting reference to the Canadian situation.

The worldwide demand for forest products is predicted to keep growing in the future. The trend in demand is towards an increased range of more value-added and ready-to-use products. This trend presents new opportunities and challenges for wood preservation industry. Also the changes in wood rawmaterial resources and building practices will increase the importance of wood preservation in the future.

Wood preservation industry, as well as forest products industries in general, is characterized by slow renewal and development, relatively low level of technology, rawmaterial and production orientation and long life span of processes and products. The input in research and development has been rather modest and directed towards improvements in established technologies and products.

In order to seize the future opportunities, major changes are needed which emphasize the role of R & D and the need for increased investment in research. New and more high-quality technologies have to be developed and adopted in order to improve the productivity. In order to ensure the competitiveness of the products an orientation into product development and faster product renewal is needed based on the knowledge of customers' needs and improved service to the customers.

Environmental issues have become key factors in the present and future considerations for wood preservation industry. Even here, research and development has a central role to play in overcoming the problems. Research can and has produced facts to support the industry's case in removing unwarranted fears and accusations. On the other hand, products, processes and practices can be developed environmentally safer when justified. With the growing awareness of these issues, considerable new developments and improvements have already been achieved.

2. Wood preservatives

The established choice of wood preservatives worldwide includes creosote oil, CCA (and other salt preservatives) and organosolvent preservatives.

<u>2.1. CCA and other salt preservatives</u>

Even if highly fixing CCA preservatives have an excellent service record for about 40 years, their safety has been seriously questioned both by the authorities and the consumers.

The toxicity of CCA has been extensively reviewed in many documents and among others, by the Environmental Protection Agency EPA in the USA (1). The main concern generally seems to be about the arsenic which (as well as the chromium) is regarded as a carcinogenic chemical.

Recently the EPA has re-evaluated arsenic and, according to the information from the Society of American Wood Preservers, has determined, that the cancer risks of arsenic are only one-tenth of what it originally estimated in 1984 (2).

Plenty of evidence has been produced to show that the risk of environmental pollution by CCA treated timber after fixation is negligible. However, additional surveys, data and analysis results are still required for the reliable assessment of the safety and performance of treated timber in service.

Unfortunately, careless handling of CCA preservatives has been practiced in earlier days in many treatment plants. This has caused a need for developing and adopting measures to clean the polluted sites, which often are both expensive and difficult to perform.

Despite of the health and safety and environmental concerns, the use of CCA in wood preservation has been growing steadily worldwide. At the moment no alternative preservatives are known that could be used to fully compensate for CCA treated timber in ground contact.

While CCA preservatives have very good effectiveness in softwoods, some treated hardwoods perform poorly. The reasons are still unsolved and call for further research.

2.2. Creosote oil

The toxicity of creosote oil which was long considered low has also become a serious concern. The main attention has been focused into the contents and toxicity of polynuclear aromatic hydrocarbons (PAH) in creosote oil.

Also in Finland, the chemical compositions of creosote oils imported to Finland have recently been examined (3). In addition, the contents of creosote vapors and PAH aerosols in the air of treatment plants and places for handling treated timber have been measured (4). The exposure of workers to creosote vapors (from 0,1 to 11 mg/m^3, average for 8 hours) was in general clearly lower than the contents known to be harmful. The benzo(a)pyrene (BaP) contents measured varied from less than 0,01 to 0,03 ug/m^3 at different working phases.

Creosote specifications have lately been successfully developed towards environmentally safer compositions without decreasing the efficiency (5). In addition to lower toxicity, attention in the choice of creosote compositions is also paid to the reduction of bleeding. Bleeding can also be reduced by technological adjustments of the treatment program, for instance by prolonging the final vacuum. The Finnish Wood Preservation Association has had a pilot line of creosoted poles installed in order to compare the effect of creosote compositions and treatment programs on the bleeding of creosote from poles in service.

In Australia, a development of pigmented emulsified creosote has been reported, which improves the surface cleanliness of treated timber (6).

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2.3. Organic solvent preservatives

Pentachlorophenol (PCP) has been banned in some countries, for instance in Sweden, and its use has been restricted in many countries. The reasons for the restrictions are both the toxicity of PCP and possible dioxin impurities present in PCP preparations or produced during treatment of wastes.

The main alternative to PCP has already long been tri-n-butyltin oxide (TBTO). In the Nordic countries, organic solvent preservatives include mainly TBTO as an effective component. Some include tributyltin naphthenate (TBTN) or copper naphthenate (CuN) and in some products organic tin is combined with other organic fungicides like dichlofluanide.

Triorganotin products are mainly used for the treatment of exterior joinery and other wooden constructions above ground. TBTO has been shown to decompose in wood during aging. However, the performance record of the treated joinery in the Nordic countries and all around the world is good this far. Research is in progress to get a better understanding of the behavior of organotin preservatives.

Other effective components used in organic solvent preservatives include alkyl ammonium compounds (AACs) and copper-8-hydroxyquinolinolate (Cu8). Water repellant additives are often used to improve the performance of the preservatives.

The light organic solvents alone can cause health and environmental problems at the treatment plants. These problems have been diminished by developing treatment and drying processes. There is also a trend into the use of water-based formulations whenever possible. Most of the active ingredients used in organosolvent preservatives can also be formulated into water-based preservatives (7).

In the product development, it seems much easier to select and develop new chemical for the above-ground use than for the ground-contact use. Therefore, the choice of preservatives there is larger and much development work is under progress.

2.4. Antisapstain preservatives

As well as PCP in the organic solvent preservatives, chlorinated phenoxides used for the prevention of stain and mold on sawn timber have become less and less acceptable.

For instance in Finland, the sawmilling industry has completely given up the use of chlorinated phenoxides due to environmental reasons and problems connected with the export of PCP treated sawn timber. The preservatives currently in use contain mainly alkyl ammonium compounds (AACs) and also methylene-bis-thiocyanate (MBT) and 2-(thiocyanomethylthio)benzothiazole (TCMBT).

In Finland, problems have arisen due to the careless handling of chlorinated phenols practiced earlier at some sawmills. The sawmill sites, soil and even ground water, may have become polluted, which calls for extensive and expensive cleaning operations.

3. Treatment methods

3.1. Pressure treatment processes

It has often been stated, that the pressure treatment processes currently in use are all actually modifications of the original Bethell process patented in 1838. It must be underlined, however, that by several technical improvements in plant design and control, in mechanization and automation, the efficiency and the productivity of the process has been improved and health and environmental risks have been diminished.

An example of developments into environmentally safer processes is the steam fixation of CCA and other chromium containing preservatives studied recently in BFR Hamburg (8). Almost total fixation of Cr^{6+} is reported to be achieved by hot (100 - 120 °C) steam with no significant reduction in the strength of treated wood or in the efficiency of CCA in softwoods.

Drying of timber before pressure treatment increases production costs and particularly in the case of air seasoning, slows down the production and causes need for pretreatment storage. Sap displacement techniques in various modifications are still in use mainly for the treatment of timbers difficult to treat in dry condition, but they tend to be more inconvenient to manage and need freshly felled timber. The oscillating pressure method (OPM) originally developed in Sweden in 1940's allows the treatment of partially seasoned timber. According to recent German investigations, a sufficient penetration in spruce can be achieved at least with wood moisture content of 60 % (9). In New Zealand, the process has been modified and called APM (alternating pressure method), and is in extensive use.

3.2. Non-pressure processes

Recently, research interest has also increased again regarding further development of diffusion treatments of timber. In order to be applicable in modern industrial practices, the diffusion treatments should be developed more rapid and easier to control. The advantages include the possibilities to treat refractory species like spruce, both sapwood and heartwood, moist and partially seasoned timber, and to use diffusible low-toxicity preservatives like boron compounds.

Diffusible preservatives are, however, often poorly fixed and easily leached out of wood by water. One way to improve fixation is double diffusion treatment (10).

3.3. Treatment of refractory species

Treatment of refractory species has continuously been one of the main problems for wood preservation research. In Europe, the treatment of dry spruce (Picea abies Karst.) has been extensively studied, in recent years in collaboration with the European wood research program and with the Nordic research institutes as well. Several techniques have been developed that improve the retention and penetration of preservatives. These include incising, perforations and enzymatic pretreatment as well as high pressure and pulsating processes (11) and optimization of pressure treatment programs. Nevertheless, full penetration in dry spruce cannot be reached with the existing methods.

On the other hand, it seems obvious that also partial and envelope treatments of spruce give satisfactory performance particularly in above ground conditions. This is partly attributed to the favorable moisture behavior (slow absorption of water) of spruce constructions, which has been confirmed in many tests and in service (12). Therefore, in the Nordic countries and in the connection of the European standardization, specifications for spruce treatments are being drafted. Problems are caused by the difficulties of the microbiological assessment of partial treatments (13) as well as by uneven absorption and penetration of preservatives in spruce timber.

4. Preservation of wood-based panels and composites

There are three main alternative principles for the protection of wood-based panels and composites:

- treatment of wood raw material by dipping, spraying or pressure treatment before assembling the composite
- incorporating the protecting agents in the glue mixture
- treatment of finished products by dipping, spraying or pressure treatment.

A comprehensive overview on the protection of wood-based composite products was given in the special IUFRO (International Union of Forestry Research Organizations) Symposium arranged in the connection of the IRGWP (International Research Group on Wood Preservation) meeting in Honey Harbour, Canada, in 1987 (14).

In the manufacture of wood-based panels, mixing the preservative with the glue is the most convenient and mainly used method of treatment. If for instance in plywood, thick veneers are used, the protection achieved this way is not sufficient for heavy hazard situations. Pressure treatment of wood components or finished products causes more problems in the manufacturing line. In the treatment of finished boards, complete penetration is not easily achieved. Surface treatments improve the resistance of composite materials to mould and stain fungi, but do not give good protection against decay.

5. Treated timber in service

5.1. Drying of impregnated timber

The need for drying of timber treated with water-borne preservatives into the moisture content appropriate for the end-use is increasing both due to environmental safety considerations and to users' needs. In kiln-drying of CCA treated timber, problems are caused by uneven distribution of the final moisture content in wood in spite of considerably increased drying times and by increased checking and other drying defect. The Swedish Wood Preservation Institute has during recent years had several research projects on kiln-drying of treated timber (15). Further studies are still needed for the determination of optimal drying schedules for different products in different types of kilns.

Also special drying systems have been studied for the drying of treated timber, including high temperature steam drying under vacuum (Danish Wood Treating Company process) and high temperature drying in oil under vacuum (Hager K process) (15).

5.2. Maintenance of treated timber in service

In the choice and economic evaluation of products, also maintenance costs are more and more taken into account. Poles and sleepers are typical long-life products, where the role of maintenance is important. Maintenance schedules for poles have been developed including recommendations for remedial treatments.

An essential basis for the planning of maintenance measures is to ensure the complete fulfillment of quality specifications originally in the production. Reasons of early failures of treated poles in service often lie in original treatment failures. There are indications that increased attention in the quality control of poles should also be paid to the quality of raw poles and to the prevention of biological damages during pretreatment storage.

In order to facilitate maintenance inspections, reliable and easy-to-use nondestructive methods are needed for the detection and determination of decay in poles in service.

Several different devices have been developed for the purpose, but none of them can still be trusted as a sole criterium of inspection. In Finland, different methods have been recently reviewed (16) and available devices are being tested and compared for the detection of decay in poles in service.

5.3. Product development

In the building field in the future, more diversified, more value-added products ready to be assembled will be needed with exact performance and durability specifications. This means that the wood preserver must ensure better knowledge on these specifications and end-use requirements even if they would not be producing final products or product systems but components or treatments to such systems. Another result is, that the diversity of various treatments tends to increase, each product or group of products having treatments better tailor-made for the particular end-use.

In the field of product development, in addition to the development of preservation, surface treatments of impregnated timber should be developed further particularly in order to improve the resistance to weather and diminish the need of reapplication. Combinations of water-repellant treatments and preservation treatments need to be developed. Consumers would also like to have impregnated timber in different colors.

6. New approaches to wood protection

Completely new innovations in the field of wood preservation can only be found by increased input and strengthening of basic research. Better understanding of the basic structure and chemistry of

wood, biodeterioration processes, interactions and succession of micro-organisms, reactions and movements of chemicals in wood and the action mechanisms of wood preservatives are needed in scientific-technic search for new approaches and ways to prevent biodeterioration and to improve the durability and performance of wood and wood products.

New approaches to wood protection could include specific means to control the fungal metabolism, wood modification or biological control.

If the fungal metabolism and the biodeterioration processes are completely clarified, several specific possibilities can be revealed to inhibit, interfere with or regulate the enzymatic processes without using generally toxic substances.

By chemically modifying the wood substrate, the highly specific enzymatic reactions involved in biodegradation can be hindered. Modifying the cell wall polymers to make them more hydrophobic or bulking them with bonded chemicals can also help to protect wood from biodeterioration by reducing the hygroscopicity of the wood cell wall.

In the biological control, "harmless" non-degrading organisms are used that are antagonistic to wood destroying organisms. Certain bacteria and moulds for instance have been used to control the growth of decay fungi.

7. Standardization

In the field of wood preservation, world-wide efforts for common standardization have been very limited. This is of course mainly due to the great variation of raw materials, damage potential and building practices around the world. However, with increasing international trade in treated products and preservatives international standardization is getting more and more actual.

The development of completely integrated European market for industrial goods till the year 1992 is today one of the major issues for the European economy. Also wood preservation industry can be expected to benefit considerably from this development. At present, the work towards the harmonization of standards and development of common test methods is most urgent and claims for plenty of resources.

The organizations particularly involved in this work are CEN (Comite' Européen de Normalisation) and EHC (European Homologation Committee).

As the basis for the harmonization a hazard classification has been developed. The need of preservative treatments is evaluated for each hazard class. Test methods are being chosen or developed for the determination of the efficacy of wood preservatives for different hazard classes. Treated wood is standardized for different hazard classes either by specifying the treatment or by the requirements for the penetration and retention of the preservative. Quality control and branding of standardized products will be carried out according to common principles (17).

8. International co-operation

Most of the problems and challenges in wood preservation research are worldwide. Research work to solve the problems is getting more and more demanding and expensive. Therefore, the role of international co-operation through organizations like the IUFRO and the IRGWP is of great value in this work. The lively co-operation within the IRGWP between researchers from various research institutes, universities and the industry has proven particularly fruitful. The progress of this group has been recently summarized by Cockcroft (18).

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